accelerator operations

Accelerator Operations

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The LANSCE user facility restarted with maintenance activities on January 2, 2003, after the annual Laboratory holiday closure. Beam operations resumed on January 7, 2003, and continued to all experimental areas for 20 days, culminating on January 26, 2003. LANSCE Operations staff confirmed the existence of a significant problem with the cooling systems on the drift-tube linear accelerator (DTL) tanks during this period. Maintenance and enhancement activities were then performed during the LANSCE user-facility scheduled outage from January 27 through June 8, 2003. This outage was followed by accelerator turn-on (including testing of the DTL tanks), commissioning of the Switchyard Kicker (SYKI) system, and contingency time that culminated in the start of full user-facility operations on July 28, 2003. Operations continued through December 23, 2003, and were then suspended for the annual Laboratory holiday closure. Operations resumed on January 2, 2004, and the 2003/2004 run cycle concluded on April 25, 2004.

2003 Outage Execution

The 2003 outage was planned beginning in the last quarter of 2002 to both coordinate and level personnel resources across major tasks selected for the outage. This planning, which had to be modified significantly in early 2003 to accommodate the remediation work for the DTL, allowed the accelerator turn-on to begin on June 9, 2003, approximately one month after the date originally planned in late 2002. First commissioning activities for the much-anticipated SYKI system began on July 3, 2003. First beam was delivered to the Proton Storage Ring (PSR) on July 4, beam delivery to the Weapons Neutron Research (WNR) facility began on July 5, and first beam was delivered to Area C on July 9. Full commissioning of the SYKI system began on July 10 and was completed successfully by July 23. Full user-facility operation began as promised on July 28, 2003. Key tasks that were completed during the outage included

- fabrication, assembly, installation, testing, and commissioning of the SYKI system;

Activity description	Early start	Early finish
Turn off accelerator and begin outage	26JAN03A	
Install and test I&C for IPF	27JAN03A	15MAY03
Install switchyard kicker system	27JAN03A	19MAY03
Basic accelerator and facility maintenance	27JAN03A	09JUN03
Re-establish beam - Target 2/4 exp. area		01JUL03
Re-establish beam - Lujan exp. area		17JUL03
Re-establish beam - Line X/B/C exp. area		17JUL03
Full system commissioning	10JUN03	29JUL03
Production beam to all areas		29JUL03
Continue UCN - installation and commissioning	27JAN03A	30OCT03
Continue auth. basis documents (DSA/SAR)	01OCT02A	30APR04

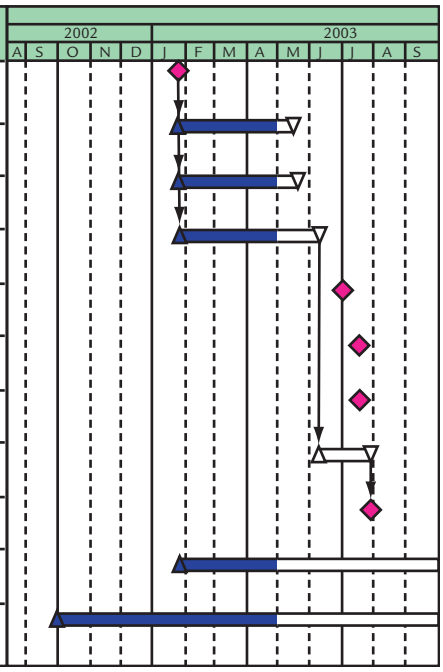

Figure 1. A portion of the 2003 outage schedule, including activity descriptions and duration.

- rehabilitation of the DTL tank-wall cooling systems by flushing with acid, following extensive studies of flow patterns, cooling efficiency, and related thermal-hydraulic system measurements;
- installation and testing of instrumentation and controls for the Isotope Production Facility (IPF);
- continued development of planned Documented Safety Analysis (DSA) documentation for the nuclear facilities and activities at LANSCE and development of a planned Safety Assessment Document for the LANSCE accelerator and non-nuclear portions of the LANSCE user facility;
- continued installation of the ultracold neutron (UCN) target shielding monolith and associated rebuilding of the Line B beam line;
- essential, high-priority accelerator and facility maintenance;
- selected lower priority accelerator and facility maintenance; and
- successful turn-on of the accelerator and beam-delivery systems.

The outage was once again managed as a project, and over 1,500 activities were scheduled and completed. A high-level summary schedule is shown in Figure 1. Substantial effort was devoted to fabrication, assembly, installation, testing, and commissioning of the SYKI system. This project was completed on schedule and worked extremely reliably and as designed during the 2003/2004 operating period. The SYKI system met its intended goal of increasing the time available to the Lujan Center and the WNR facility by about four days out of each 28-day ion source maintenance cycle while providing continuously available beam to the proton radiography (pRad) program in Area C. The performance characteristics of the "kicked" pulses to Area C have met all the technical requirements of the pRad program.

The most challenging technical issue addressed during the outage centered on the resolution of the overheating problem of the DTL tanks. A fiber-optic bore-scope clearly showed a thick layer of iron oxide deposited on the cooling channels of the iron tank walls. Several fully and partially obstructed cooling channels were also identified on the tank post-couplers used to stabilize and tune the radio-frequency fields in the tanks. These cooling passages were cleaned with a custom acid solution using a procedure developed in consultation with an external expert advisor. The cooling passages of the copper drift tubes were also examined, but these were sufficiently clean that it was decided not to risk damage to the drift tubes by flushing that system with an acid solution. The tanks have operated well after initial tests to verify that the cleaning activities were successful. Engineering deficiencies were also identified on the post-coupler cooling manifolds, and a prototype replacement system was implemented for one subsection of this system. A thermal image of the tank-wall cooling is shown in Figure 2. This activity resulted in an

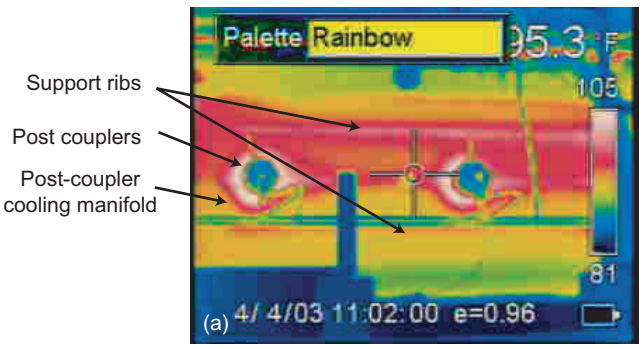

Figure 2(a). Thermal image of the side of Module 2 during poor operation at 90 Hz before flushing the tank walls.

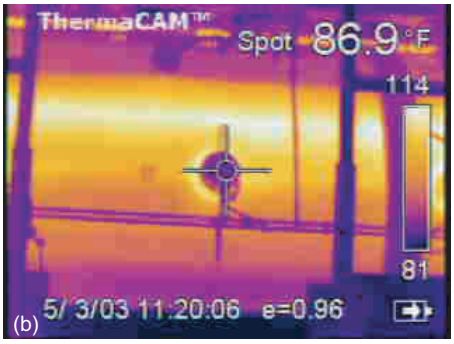

Figure 2(b). Thermal image of the side of Module 2 during good operation at 120 Hz before flushing the tank walls.

approximate one-month slippage in the start-up date when compared with plans generated in November 2002. Despite this delay, accelerator turn-on went smoothly after start-up.

The readiness assessment for the IPF was conducted after user-facility operations resumed, and first beam was delivered to the IPF target station on December 23, 2003. The formal dedication of the IPF and the start of full commissioning activities were scheduled for January 2004.

Very good progress was made on the development of the Authorization Basis documents, and LANSCE expects to deliver the final products to the Department of Energy as scheduled in 2004.

Integrated efforts to formalize long-range planning continued, and a predictable operating schedule for the 2003/2004 operating period was developed. Several changes were made to the operating schedule in response to delays in the readiness of the IPF to receive beam. LANSCE also continued the policy of limiting scheduled periodic maintenance activities to four days (with two exceptions), permitting restart of the user program before the weekend. LANSCE also continued the policy of scheduling two blocks of contingency time amounting to a total of 15% of the scheduled beam time, the first placed at the halfway point of the operating period and the second at the end of the operating period. This arrangement better addressed reclamation of lost time for some experiments and also allowed the prompt scheduling of new, urgent experiments. The installation of the SYKI system eliminated the need for sole-use activities, defined as any research and development use of the LANSCE accelerator that precludes or interferes with beam delivery to the Lujan Center or the WNR Facility. Instead, clearly defined periods were allocated to address the single remaining beam-utilization conflict within the user facility: delivery of beam extracted from the PSR to the WNR Facility Target 2. This activity precludes delivery of production beam to the Lujan Center. There is no immediate technical solution to this beam-sharing problem, and it will continue to be addressed through scheduling means. Two machine-development days were allocated on the final weekend before the maintenance days; this proved to be important to address machine-alignment and beam-loss issues that were identified during the operating period. A prototypical 28-day cycle is shown in Figure 3.

2003 Operations and Beam Delivery

Operations in January 2003 were highlighted by increasingly frequent trips of flow switches and thermal interlocks on the DTL tanks and post-coupler cooling systems. The root cause of these problems was identified during the outage, and remedial actions were taken as described above.

The successful installation and commissioning of the SYKI system enhanced operational flexibility, and together with improved operation of the DTL tanks, supported a very productive operating period in calendar-year (CY) 2003. LANSCE again met its commitment to deliver six months of beam to users in CY 2003, delivering beam in January and then again in August through December.

Operational achievements are summarized in Figures 4 through 9. Overall beam reliability during the CY 2003 run cycles for all areas is summarized in Table 1.

The portion of the operating period in the fall of 2003 proved to be one of the more challenging in recent history. August 2003 was a particularly poor month, as shown in Figure 4. The facility experienced four substantial lost-time events during this month. A malfunction of the fire-protection system associated with a water-hammer event resulted in a fractured water main pipe at LANSCE, with an associated fire in a pump house. This was followed almost immediately by a significant Laboratory-wide power outage that damaged accelerator equipment. A vacuum-valve o-ring in the Low-Energy Beam Transport (LEBT) rolled out of its slot and intercepted the beam, resulting in significant beam loss and a lengthy downtime. Finally, a water-to-vacuum leak occurred on a cooling loop embedded on the radio-frequency end-wall of the Module 1-2 intertank spacer in the DTL. This inaccessible leak was repaired with a patented leak sealant LANSCE purchased a license to use some years ago. These four events contributed to a reduction in beam reliability of 5% for the 2003/2004 operating period.

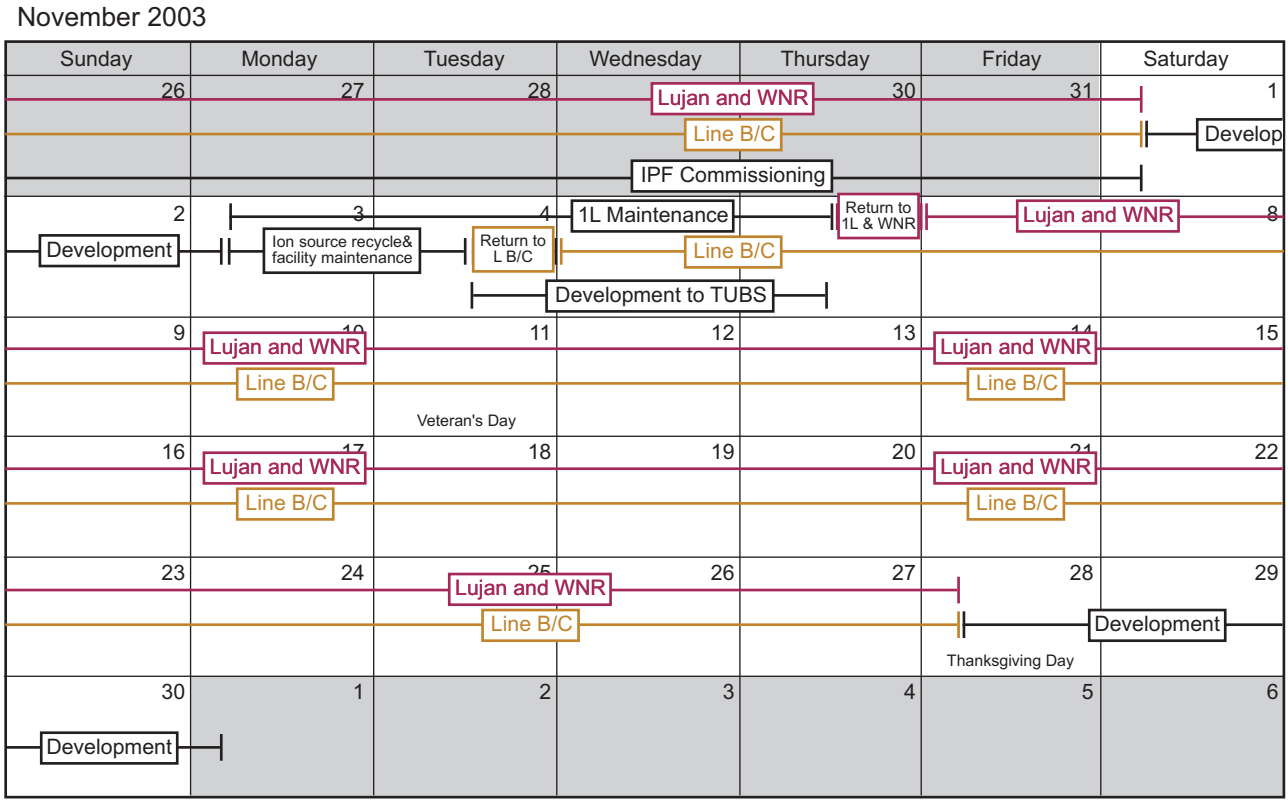

Figure 3. A prototypical 28-day cycle (November 2003).

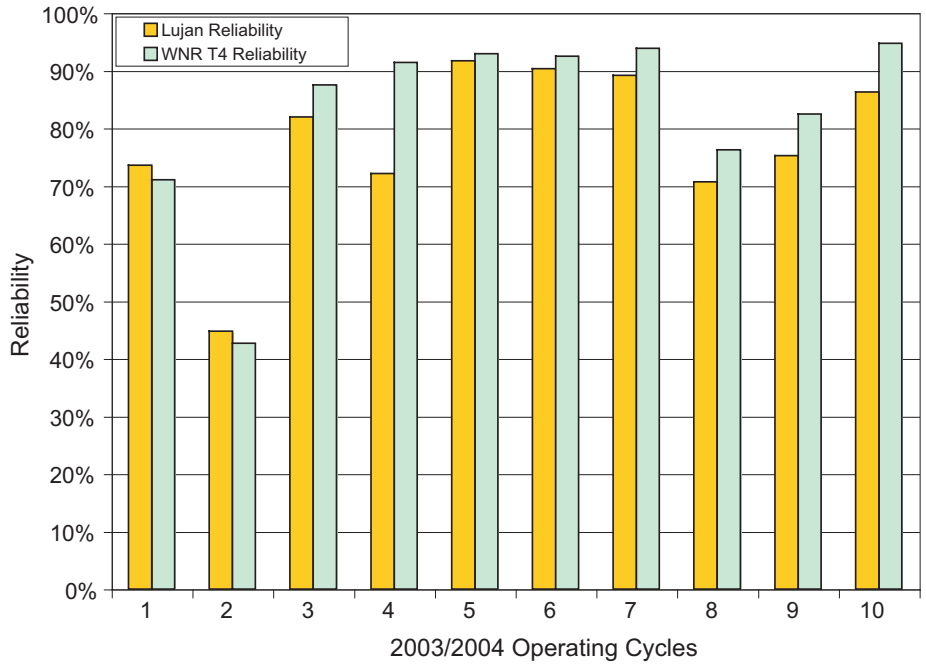

Figure 4. Beam reliability for each 28-day operating cycle in CY 2003.

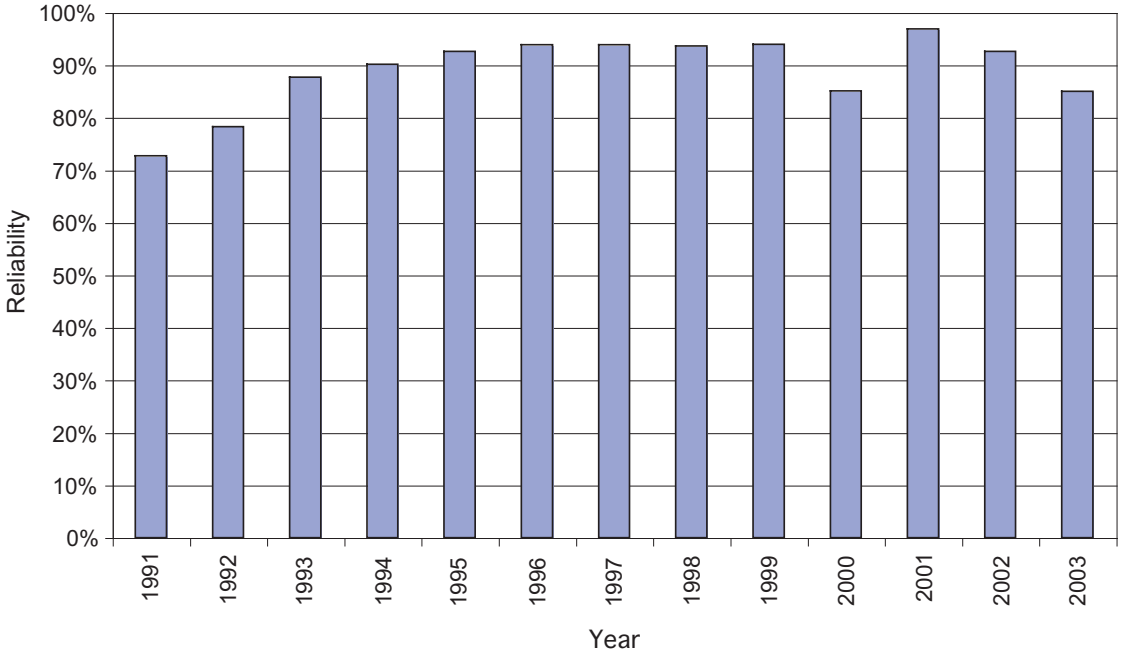

Figure 5. Accelerator reliability for Lujan Center operations.

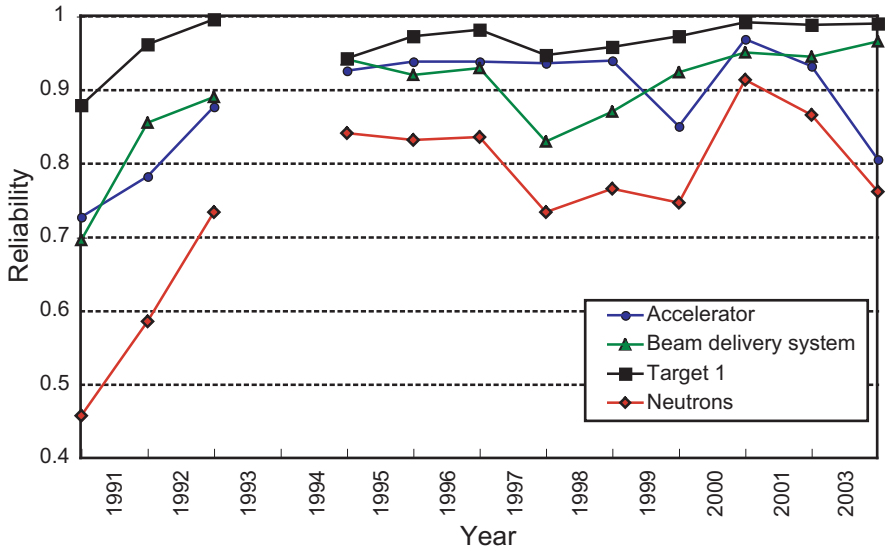

Figure 6. Subsystem reliability for Lujan Center H^- beam delivery by calendar year.

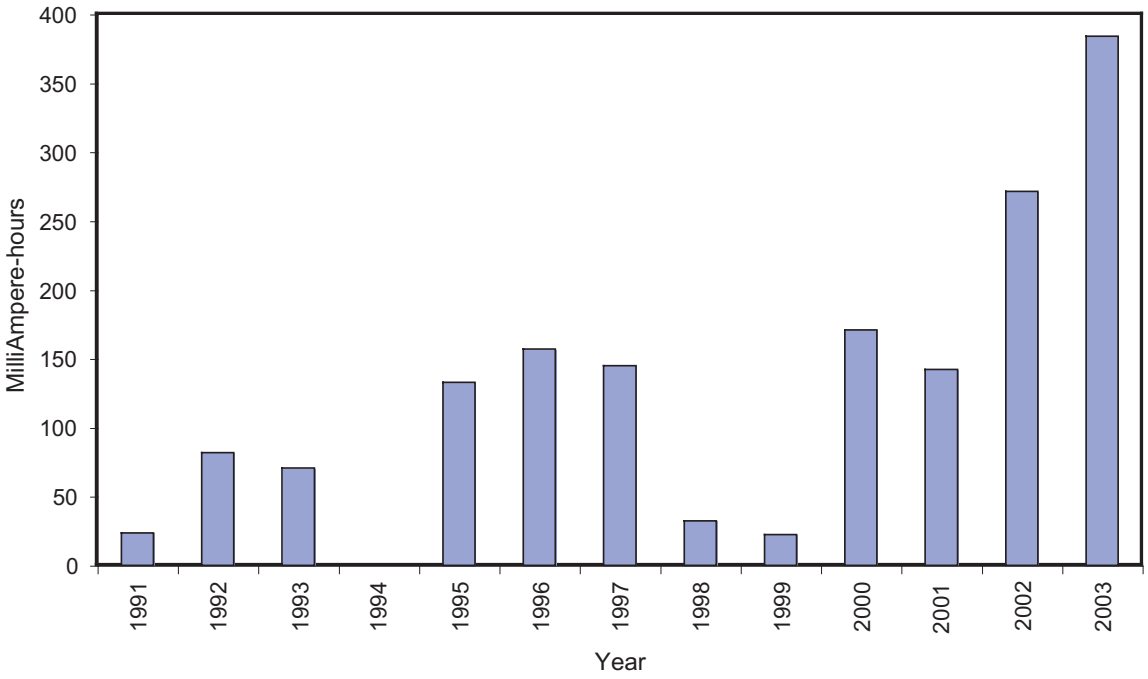

Figure 7. Integrated beam charge delivered to the Lujan Center by calendar year.

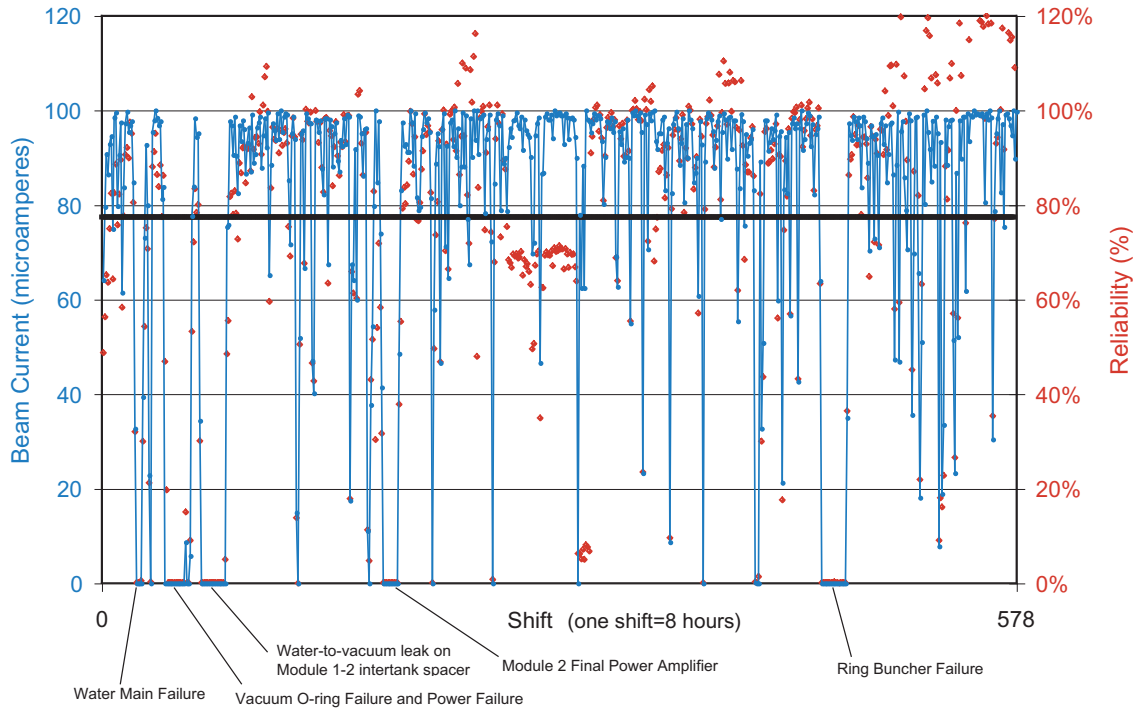

Figure 8. Lujan Center beam current and reliability for calendar year 2003.

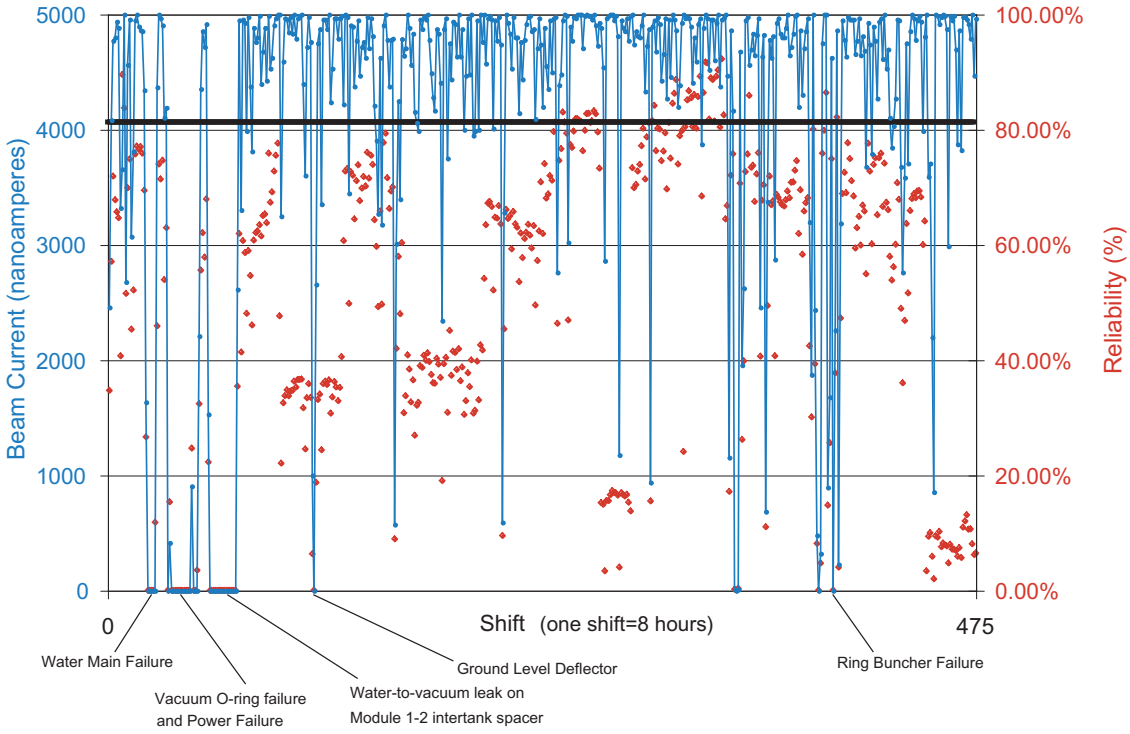

Figure 9. WNR Target 4 beam current and reliability for calendar year 2003.

Table 1. LANSCE beam delivery for the 2003 run cycle.

Area	Delivery Dates	Scheduled Hours	Delivered Hours	Reliability
Line-X/B/C	07/29/03 to 04/20/04	826.3	659.8	79.9%
Lujan	07/28/03 to 04/21/04	4509.1	3476.0	77.1%
WNR Target 2	08/07/03 to 04/12/04	634.2	485.1	76.5%
WNR Target 4	07/28/03 to 04/21/04	3726.4	3018.7	81.0%

Another significant issue that was confronted during this time was increased beam loss in the first 200 meters of the accelerating structure. The beam quality entering the PSR was also not of the usual quality. Extensive machine development was done during scheduled development time to understand the origin of these difficulties. Measurements of the position of components inside the accelerator tunnel indicated that there were clear misalignments of accelerator components relative to each other in this region of the machine. This information formed the basis of a detailed realignment plan that is being developed for the 2004 and 2005 outages.

Nevertheless, all facilities received quality beam during the CY 2003 period, with the Lujan Center routinely operating at 100 microamperes and the WNR facility receiving beam as planned.

The pRad program continued its stellar record of beam delivery for every dynamic shot performed in CY 2003.

2004 Outage Planning

Planning for the 2004 outage began in December 2003 and is in the initial stages. Detailed planning will take place in early 2004, and the key tasks remain to be defined. It will be important to address equipment-alignment issues at several places in the facility. Development and finalization of the Authorization Basis documentation will take substantial effort, as will development of an implementation plan for the requirements specified in these new documents. LANSCE plans to continue its practice of managing the outage in a formal way with project management tools and change control.